

Introduction



The Big Picture

Overview

A Global Positioning System (GPS) receiver is a hand-held device that receives data directly from overhead satellites. With a GPS receiver, students can determine their location, as measured in latitude and longitude, almost anywhere in the world to an accuracy within 100 meters. If they average several measurements, typically they can determine their location to within 30 meters, which is the size of a single Landsat image pixel. Thus, students can determine the location of their 30-by-30-meter GLOBE study sites with sufficient accuracy to identify their unique pixel in Landsat images.

Yes, students will use satellite data. Although it was originally designed for military uses, GPS is now used primarily in civilian applications. As a part of GLOBE, we want your students to determine the latitude and longitude of their school and study-sites. These data will locate the sites of their biosphere measurements and will be used by scientists and students worldwide. If you do not have access to a GPS receiver, then the GLOBE Program can assist you in borrowing one. If you are at a U.S. GLOBE school, then the GLOBE Program can loan your school a hand-held GPS receiver. If you are at a non-U.S. GLOBE school, then you can borrow a GPS receiver from your country coordinator. See GPS Investigation Part II for details.

Satellites

Many types of spacecraft exist. Unmanned scientific spacecraft such as Magellan, Viking, and Galileo have been sent to Venus, Mars, and Jupiter to perform physical measurements and relay their data back to Earth. Voyager 1 and 2 continued out of our solar system in the 1980's after observing several of the outer planets. In 1995, the Galileo spacecraft dropped a probe into Jupiter's atmosphere. While it passed through the atmosphere, withstanding intense atmospheric

pressure and temperature, this probe radioed its sensor information back to Galileo, which in turn relayed it back to Earth.

Manned spacecraft such as the Apollo series, Space Shuttles, and the Mir Space Station have people onboard. Unlike unmanned spacecraft, these vehicles need to provide an atmosphere, temperature control, food, and the other facilities necessary to support human life. For these and safety reasons, manned spacecraft typically are much more expensive and complex than unmanned spacecraft. However, the presence of people in space provides an opportunity for our human ingenuity to handle unplanned events in addition to allowing us to experience and enjoy being in space.

A spacecraft in orbit around a larger body is called a satellite. When the Galileo spacecraft reached Jupiter and slowed down to enter into an orbit around the planet, it became a satellite of Jupiter. When we launch a satellite into orbit around Earth, it becomes an artificial satellite of Earth just as our moon is a natural satellite of Earth. These artificial satellites in Earth orbit perform a variety of tasks including: long-distance telephone, television, and data communication, weather and natural-resource observations, military surveillance, and basic science measurements.

Our moon is 384,500 km from Earth, and it takes about one month to complete one orbit. Because of fuel limitations or a desire to perform close observations, Space Shuttles and some observation satellites are only a few hundred kilometers above Earth. These "Low-Earth-Orbit" satellites take a minimum of 90 minutes to complete one orbit. Communications satellites are in orbits 35,792 km above Earth. At this altitude, these satellites take exactly one day to circle Earth. This special orbit is called "Geosynchronous Orbit." A satellite in geosynchronous orbit always appears to be at the same place in the sky to a terrestrial observer. Thus, an antenna pointed at a geosynchronous satellite need not move.

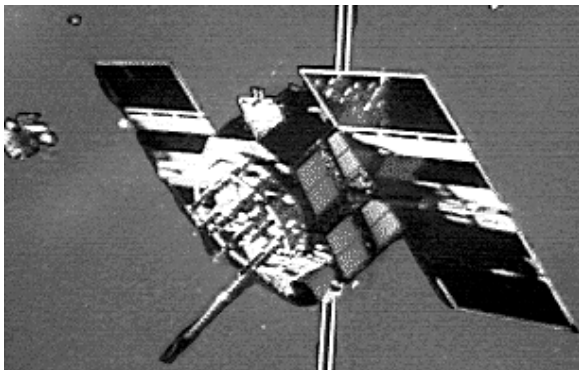


Figure GPS-I-1: A Global Positioning System Satellite

Compare this to a Space Shuttle which may pass from horizon to horizon in minutes or our moon which may take a month to move across the sky.

GPS Satellites

The Global Positioning System consists of a series of satellites, their ground control stations, and users with GPS receivers. See Figure GPS-I-1. These satellites are unmanned. They are launched by expendable rockets that place them into orbit. There are 24 GPS satellites in orbits 20,200 km above Earth's surface. At this altitude, the satellites take about 12 hours to complete one orbit. The satellites are spaced in their orbits so that at least four are always in view of a terrestrial observer at any point on Earth.

Powered by solar cells, the GPS satellites contain a controlling computer and communicate with the Earth via radio. Each satellite contains four atomic clocks, which are so accurate that they differ by only one second in 150,000 years. These clocks generate the time signals that are transmitted from each satellite. Software executed by a computer in a GPS receiver locks onto the timing signals from at least four satellites to determine the receiver's latitude, longitude and elevation. The receiver can be on the ground, at sea, in the air, or in space.

As a testimony to its increasing popularity and utility, the Global Positioning System was the cover story for the February 1996 issue of *Scientific American* magazine (volume 274, Number 2, pages 44-50).

Preparing for the Field

Perhaps the most complicated equipment that students use in GLOBE are the GPS receivers. Some of the activities in this investigation will use the GPS receiver, which teachers and their schools can borrow from GLOBE for a week. The best way to begin using the instrumentation is to have a solid knowledge of science and mathematics and a good sense of science-process skills.

Use the GPS investigation to integrate GLOBE science with other disciplines like social studies (from the history of exploration to the dynamic differences and similarities of different cultures and peoples), mathematics, and the visual arts with emphasis placed on observational and recording skills.

Student Learning Goals

Science Concepts

The conceptual questions that frame the GPS investigation are basic to our very nature:

1. "Where am I?" and
2. "How do I know?"

A systematic approach to these questions will address:

1. *Relative to absolute geographic descriptions of a position* - from a relative description ("I am at school"), through less relative directions (North, South, East, West), to an absolute reference frame (Latitude and Longitude).
2. *Earth and its satellites* - artificial, natural, and the GPS navigation role.
3. *Data quality and instrumentation* - how and why we use instrumentation and how we might "trust" the data.
4. *Mathematics* - from measuring to geometry and trigonometry.

Science Process Skills

In the GPS investigation, students will be:

- Observing* things critically
- Identifying* patterns to determine similarities and differences in observations
- Asking* questions based on their observations
- Expressing* and *recording* observations systematically
- Manipulating, analyzing, and integrating* observations and data
- Drawing* conclusions based on the observations and data
- Communicating* observations, questions, and thoughts

Student Assessment

The GLOBE investigation provides interesting opportunities for students to become engaged in science and mathematics. Your tasks as a teacher include knowing how your students are changing in the process—how they are growing—more than how they are performing some protocol. While performance is obviously important, given the general concern for the safety of the students, the expense of some of the instruments, and the need for accurate data, the real educational key is the development of systematic and critical attitudes toward what are listed above as *Science Process Skills*. Specifically, you can evaluate the students by comparing their performance against a criteria based on the above list.

Evaluate the students as follows:

1. *Observations* – Can students pick out and list details? Can they describe what they observe?
2. *Comparing and contrasting* – Can students find differences and similarities between what they are observing now and what they observed before? How do the present data relate to past experiences? That is, where have they seen similar things? Can they explain differences, for example, in latitude and longitude, in directions or in mathematical approaches to problems?
3. *Questioning* – Can students ask questions of one another, of the teacher, or of others in the community, including the scientific community? Have your students record their questions. Encourage them on tests to write questions that they think of extemporaneously.
4. *Recording* – Perhaps the easiest way to evaluate students on skills and concepts is to see how they record in the field (during the activity), as well as after the activity. Evaluate how they record thoughts and insights, even questions, both during and after the activity, through their GLOBE Science Notebooks, essays and reports (both written and oral). The young student can record with pictures. Discussions about the pictures will provide insights into the thought processes of the student. Also, electronic recordings will be helpful in evaluation. These can range from audio and video for all levels of students, to copies of GLOBEMail messages, and computer graphing.
5. *Conceptual and critical thinking* – Will students choose to step outside of the presented framework of questions and recording tasks to generate their own models, pose their own problems, and solve these problems? While mathematical problems may be the easier for you to devise for students, you can always use “what if” or “why” questions. Activities like the modeling of the satellites or the offset GPS measurements encourage critical thinking in students. Observing and evaluating the students in the process, as to their focus, their effectiveness, and their perseverance will be helpful. Also, can they evaluate the situation for you at any given time?
6. *Communicating* – More than any other skill, this is probably the most critical for a student’s future success and the most difficult to evaluate. Evaluation of



language skills is crucial. Mathematical communication skills and interpersonal relations during the activities are vitally important at all ages. While difficult, peer evaluation techniques are particularly valuable here. Can students evaluate each other?



Your use of quality educational-assessment processes can encourage students and make a significant difference in their development.

